Atmospheric Sensing Core Competency
Relationship to the NASA Strategic Plan

- Consistent with the NASA Strategic Plan and Langley Research Center's Agency Mission in Atmospheric Science, the Langley Atmospheric Sensing Core Competency conceives, develops, and applies the advanced active and passive measurement concepts and technologies necessary to conduct the scientific research required to observe, understand, and model the atmospheric component of the Earth system and to learn how it is changing and the consequences of those changes for life on earth.

- NASA Langley Research Center pioneers the development and adoption of cutting edge active and passive remote sensing concepts and technologies that enable breakthrough research in atmospheric science providing enhanced insight into the Earth system thereby enabling mission success and accelerating the economic and societal benefits from Earth science information and technology products

Atmospheric Sensing Core Competency

Why a NASA Need/Justification for Core Competency

- The atmosphere is a key element of the Earth system and its study is crucial to the long-term health of the nation's citizens and economy. The Earth Science Enterprise (ESE) strategic plan describes the key atmospheric studies necessary to understand the Earth as a system. The Atmospheric Sensing Core Competency at Langley Research Center applies and has successfully demonstrated a unique blend of scientist-technologist-engineer-technician to conceive/identify, develop, and implement cutting edge concepts and technologies that are crucial to the success of atmospheric studies and therefore to the goals and objectives of the ESE.

- The Atmospheric Sensing Core Competency at Langley Research Center has also demonstrated the capability and desire to take on the challenge of synthesizing the research and development that occurs in the nation's universities, industry and government labs to develop a coherent program that meets the goals and objectives of the ESE mission. The Atmospheric Sensing Core Competency at Langley Research Center through its unique scientist-technologist-engineer-technician interaction has the strong scientific and technical competence required to integrate these activities and in certain areas has the core world recognized expertise.

Atmospheric Sensing Core Competency
Validation of Core Competency

Significance of Atmospheric Science Achievements

- Pioneered lidar measurements for high vertical resolution atmospheric aerosol and chemistry studies (ground based lidar-1974 LITE, LASE)
- Pioneered solar occultation (SAM-1975, SAGE, HALOE) and limb emission (LIMS) measurements for studies of stratospheric chemistry
- Developed comprehensive Earth radiation budget data set, including first cloud radiative forcing measurements (ERBE, CERES)
- Verified impact of anthropogenic emissions on global atmospheric chemistry and effectiveness of Montreal Protocol (HALOE)
- Developed fully-interactive Global Climate Model with chemistry to study chemistry-climate coupling
- Led field campaigns (GTE) to establish baseline for tropospheric chemistry studies

Atmospheric Sensing Core Competency
Validation of Core Compentency

Results of investments at Langley

- Laser technology developments enabled first lidar measurements of the Earth's atmosphere from space (LITE)
- First autonomous, high altitude (space-like) differential absorption lidar (DIAL) measurements made form ER-2, (LASE)
- High-energy, "eye safe" laser transmitter enables coherent lidar measurements of tropospheric winds from space
- Synergistic development and application of materials and instrumentation research to reduce Fourier Transform Spectrometers by order of magnitude in volume, mass and power.
- Total mission costs reduced by 10X: Enabled by compact, autonomous "sensorcraft" for Earth science applications- Gas and Aerosol Monitoring Sensorcraft (GAMS)

Atmospheric Sensing Core Competency
Validation of Core Competency

Results of investments at Langley

- Demonstrated first active inflatable/rigidizable structure using L'Garde inflatable column with embedded LaRC-MFC flexible actuators.
- Developed the CP1 clear polyimide film for space application. Being used on Hughes Communication Satellite to increase solar array power.
- Developed THUNDER and MFC strain actuators (leveraged by CETDP and predecessor). Both of these won R&D 100 awards.
- First demonstration of carbon nanotube doping of polymer film to improve electrical conductivity. Application is to reduce spacecraft charging.

Atmospheric Sensing Core Competency
Validation of Core Competency

- Internationally recognized, peer-reviewed laser technology research and development program which has development capabilities from quantum mechanical crystal modeling to breadboards to proof of concept flight laser development
- Approximately 70 laser publications (including invited papers) in peer-reviewed journals and at international conferences since last external peer review (past three years)
- Major technology transfers to industry for dental laser development, for aircraft turbulence avoidance, stable lasers for OEM products, and numerous advanced laser materials
- Personnel regularly serve as conference or session chairs at international laser, lidar, and remote sensing conferences; serve on organizing committees for same; Serve on laser mission review panels such as the Air Force Calliope and Space Based Laser Programs, NASA MBLA-VCL, IceSAT, and SPARCLE Programs
- Routinely provide detector and optics concept study support, analysis, evaluation, and development expertise for a number of Organizations, Programs, and Projects including NASA HQ, GSFC, MSFC, JPL, NMP, EOS, ESSP, and IIP

Atmospheric Sensing Core Competency
Validation of Core Competency

- LaRC led the development of the first high power, pulsed laser in space for LITE (Lidar In-space Technology Experiment) mission
  - LITE is the precursor to the current LaRC-led PICASSO-CENA mission
- LaRC conceived, developed, and assembled a tunable laser system for NASA autonomous, LASE (Lidar Atmospheric Sensing Experiment) water vapor DIAL instrument
  - LASE is currently flying in the AFWEX expedition.
- LaRC developed and provided enabling eye-safe, 2-micron laser for NASA SPARCLE (SPAce Readiness Coherent Lidar Experiment) global wind velocity mission
- LaRC has developed the highest pulsed energy (130 mJ/pulse) ultraviolet laser source for future use in global ozone DIAL measurements
  - ORACLE (Ozone Research using Advanced Collaborative Lidar Experiment) potential space mission with the Canadian Space Agency
- Developing advanced, high efficiency lasers for future space-based measurements of CO2, water vapor, tropospheric winds, chemistry and dynamics
  - <u>All technologies potentially cross-cutting to Space and Aero</u>

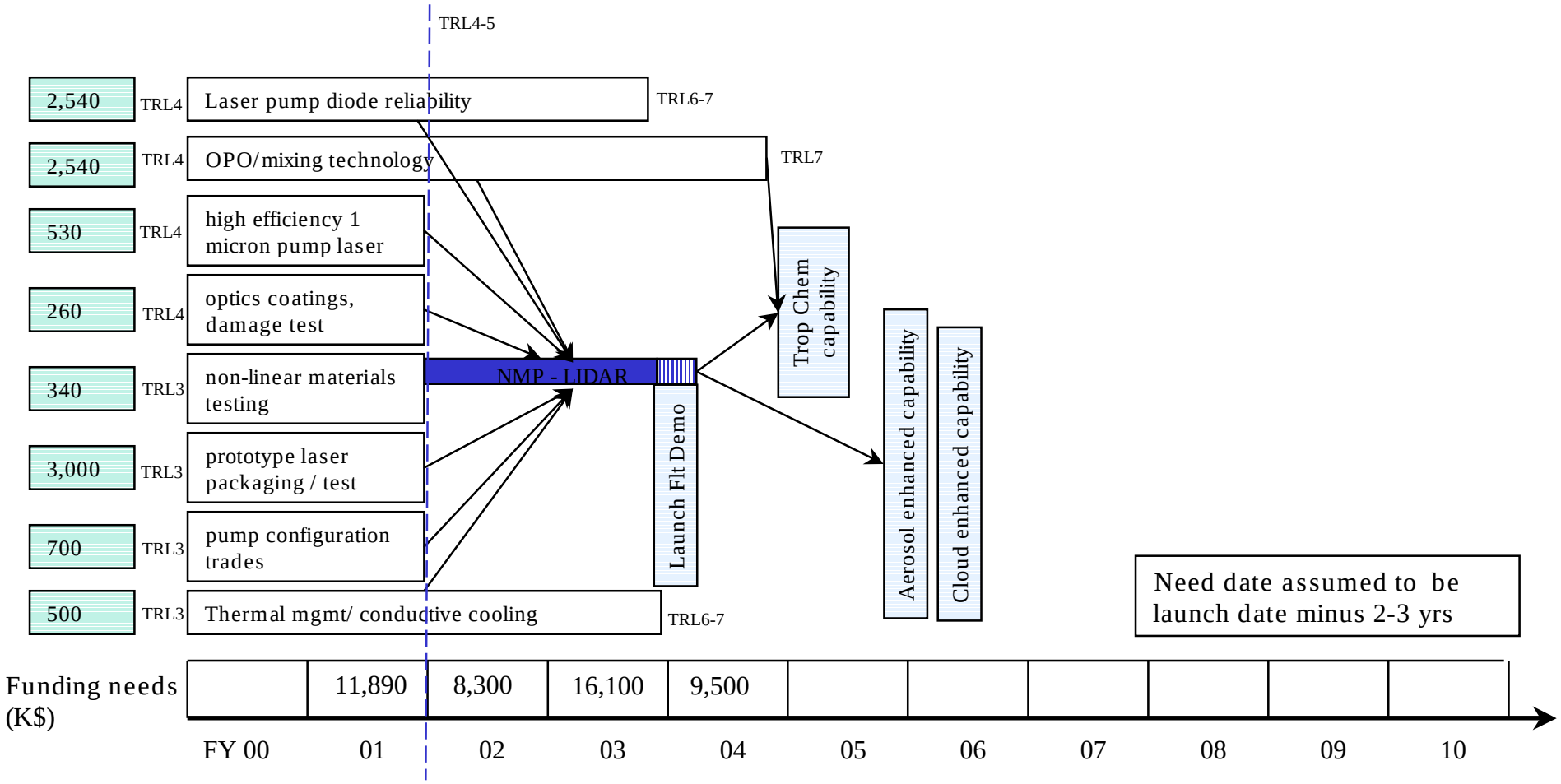
Atmospheric Sensing Core Competency

Applications to Mission: Laser and Lidar Technologies

Mission Classes / Technology		Conductive Cooled Laser Diode Pumps	Advanced Laser Materials Non-linear OPO Optical Materials	Reliable, High Efficiency Laser Technology	Laser/Lidar Demonstration
Water Vapor / Clouds&Aerosols	Earth Observation	Not funded	Not funded	X	Not funded
Spaceborne Ozone DIAL	Earth Observation	SBIR	X	X-ATIP	Not funded
Aircraft Ozone DIAL	Earth Observation	N/A	Not funded	Not funded	Not funded
Multi-wavelength Laser	Earth Observation	Not funded	X	X	Not funded
2-micron Laser for Winds/CO_2	Earth Observation	Not Funded	X-ATIP	X-ATIP	C&I funded Ground Demo
New Materials Laser Modeling & Damage	Earth Observation	N/A	Not funded	Not funded	Not funded

Atmospheric Sensing Core Competency

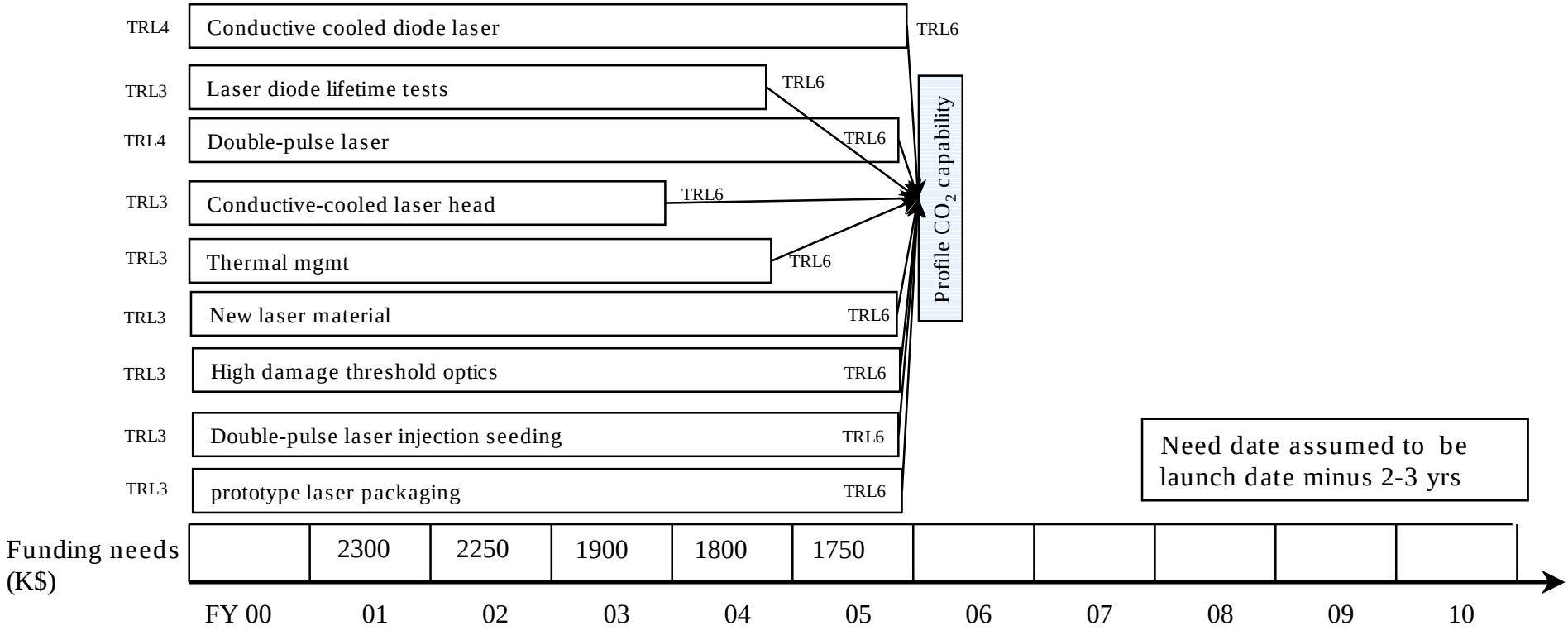
Tropospheric Chemistry/Enhanced Aerosol Radiative Forcing/ Enhanced Cloud-Radiation Feedback (includes O_3 & H_2O)



Atmospheric Sensing Core Competency

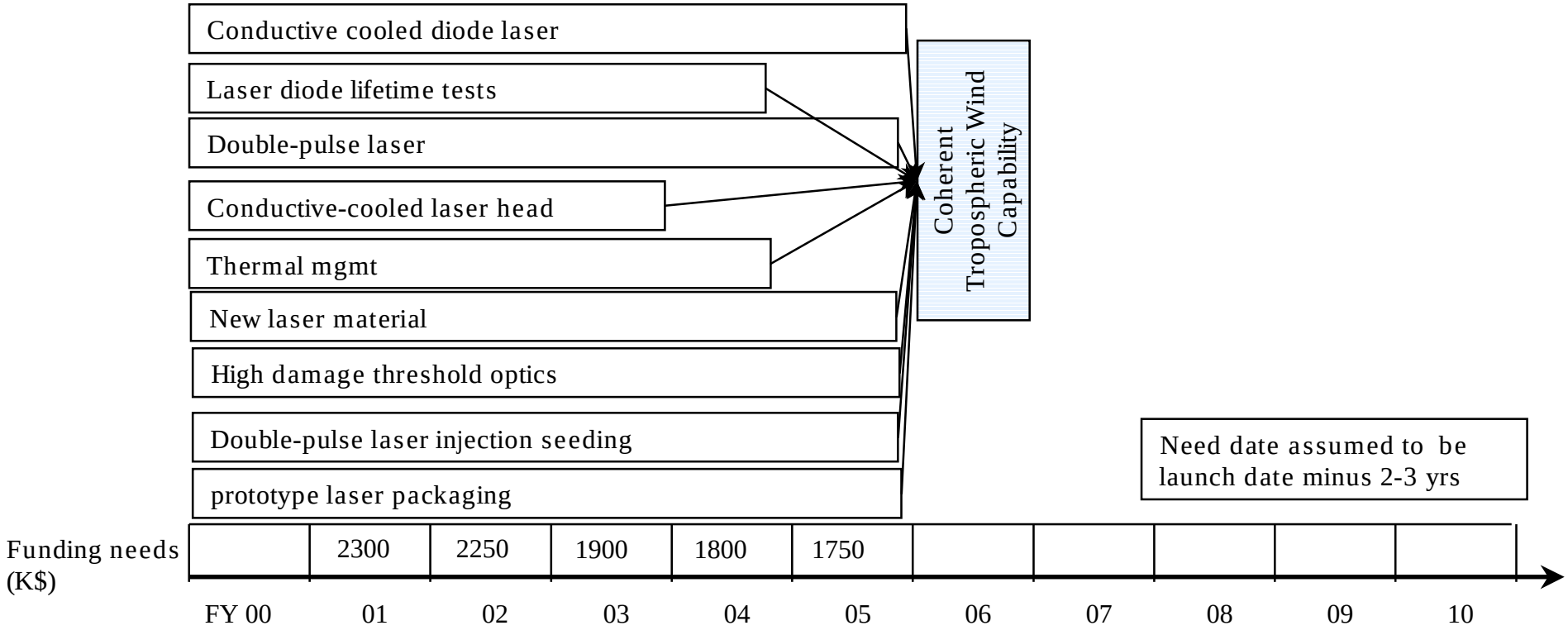
CO_2 Profile Technology Investment Plan & Roadmap

Technology/Flight Hardware	FY01	FY02	FY03	FY04	FY05	Total Additional Funding	Current Funding	Current Source
2-Micron CO2 DIAL Laser Technology	**2.30**	**2.25**	**1.90**	**1.80**	**1.75**	**8.30**	**0.55**	
Conductive cooled diode laser development	0.60	0.50	0.30	0.40	0.40	2.20	0.10	ATI
Laser diode lifetime tests	0.20	0.25	0.20	0.10		0.75		
Double-pulse laser development	0.40	0.40	0.30	0.30	0.30		0.20	ATI
Conductive cooled laser head development	0.30	0.20	0.20	0.20	0.20	1.10	0.10	ATI
Laser transmitter thermal management	0.10	0.10	0.05	0.05		0.30		
New laser material development	0.30	0.30	0.30	0.10	0.10	1.10	0.10	ATI
High damage threshold optics development	0.10	0.10	0.10	0.10	0.20	0.60	0.05	ATI
Double-pulse laser injection seeding	0.10	0.10	0.05	0.05	0.05	0.35	0.05	ATI
Prototype laser packaging	0.20	0.30	0.40	0.50	0.50	1.90		



Tropospheric Wind: Coherent detection Technology Investment Plan & Roadmap

Technology/Flight Hardware	FY01	FY02	FY03	FY04	FY05	Total Additional Funding	Current Funding	Current Source
Wind DIAL Laser Technology	**2.30**	**2.25**	**1.90**	**1.80**	**1.75**	**8.30**	**0.55**	
Conductive cooled diode laser development	0.60	0.50	0.30	0.40	0.40	2.20	0.10	ATI
Laser diode lifetime tests	0.20	0.25	0.20	0.10		0.75		
Double-pulse laser development	0.40	0.40	0.30	0.30	0.30		0.20	ATI
Conductive cooled laser head development	0.30	0.20	0.20	0.20	0.20	1.10	0.10	ATI
Laser transmitter thermal management	0.10	0.10	0.05	0.05		0.30		
New laser material development	0.30	0.30	0.30	0.10	0.10	1.10	0.10	ATI
High damage threshold optics development	0.10	0.10	0.10	0.10	0.20	0.60	0.05	ATI
Double-pulse laser injection seeding	0.10	0.10	0.05	0.05	0.05	0.35	0.05	ATI
Prototype laser packaging	0.20	0.30	0.40	0.50	0.50	1.90		



Atmospheric Sensing Core Competency
Issues and Concerns

- Critical Skill Losses
  - End-to-end laser/lidar system expertise being lost; need continuity of funding and "skilled" staff to maintain basic knowledge
  - Much of advanced laser technology development requires PhD level skills; insufficient high-grade slots available to attract/retain talent at required skill level
  - Approx. 30% existing staff at or very near retirement; replacement difficult/impossible at existing available grade levels
- Inadequate Mentors for Future Needs
  - Staff must be expanded to meet technology development requirements; not enough mentors available (see above) at PhD level
- Low Morale
  - Staff spread too thin to cover required work; prospects for high promotions low
- Critical Facilities Threatened
  - Current facilities >30 years old, clean-rooms, vacuum chambers, radiation test facilities, etc. may not be adequate for emerging electro-optical technology developments
  - Comprehensive laser damage test and analysis facilities are non-existent
- Industry Drop-Out
  - Only one quality U.S. supplier remains for **space application-critical** laser diode arrays
  - Industry not currently working on radiation-resistant laser diode arrays and/or optical coatings; many vendors are concentrating efforts on optical communication technology
  - Critical need for ultra-high stability optical mounts/optical benches and conductively cooled laser cavities